Fertility choice: the role of social externalities

Ratbek Dzhumashev[*] and Ainura Tursunalieva[†]

March 1, 2017

Abstract

This paper extends the modeling of fertility choice by incorporating the effect of social externalities defined by three factors: the average levels of consumption, fertility rate, and human capital in a society. The extended model explains the following patterns in aggregate data that are inconsistent with the existing theories: (1) The observed decline in fertility is too steep to be fully explained by the trade-off between the quantity and quality of children caused by income growth, (2) the relationship between income and fertility is shifting over time, and (3) the decline in fertility reverses at high levels of income. To test whether the effect of social externalities on fertility choice holds at the micro level, the predictions of the model are confronted with fertility survey data from the United States. The empirical results fully support the predictions of the theoretical model. The insights gained from the extended model provide a basis for enhanced understanding of fertility choice, an important factor that drives long-term growth and environmental sustainability.

Key words: fertility rate, fertility choice, social externalities
JEL codes: D1, J1, O4

---

[*]Department of Economics, Monash University, e-mail: Ratbek.Dzhumashev@monash.edu
[†]Department of Statistics, Data Science and Epidemiology, School of Health Sciences, Swinburne University of Technology, e-mail: atursunalieva@swin.edu.au

1 Introduction

Understanding the evolution of fertility choice is crucial for gaining deeper insights into long-term economic growth and sustainability. This paper aims to explain the evolution of fertility patterns observed in developed economies. We focus on developed economies because they experienced earlier industrialization and economic growth take-off that put them at the forefront of the demographic transition. More specifically, this paper rationalizes the empirical patterns that are inconsistent with existing theoretical fertility choice models. The inconsistencies between the theory and empirical evidence include the following: (i) The observed decline in fertility rates is too steep to be explained solely by the trade-off between the quantity and quality of children caused by income growth. (ii) The income-fertility relationship is shifting over time. (iii) There is a reversal of the decline in fertility in high-income economies; as after reaching some threshold, the fertility rate increases with income (see Figure 1).

The literature provides evidence about income levels affecting the rate of fertility across countries.[1] Many researchers focus on explaining a decline in fertility due to the trade-off between the quality and quantity of children caused by income growth. For example, Galor and Weil (2000), Galor (2005), and Tamura (2002) argue that a decline in fertility is caused by an increase in the return to human capital. Doepke (2004) argues that government polices influencing the opportunity cost of education explain the cross-country differences in the decline in fertility. Other researchers also point out child mortality and childcare costs are the important factors driving the quality-quantity trade-off. For example, Kalemli-Ozcan (2002) links the decline in fertility to changes in child mortality. Similarly, Kalemli-Ozcan (2003) finds that the uncertainty of child survival changes the trade-off between the quality and quantity of children, where greater uncertainty of child survival correlates with higher fertility rates. Fioroni (2010) shows that the effect of child mortality on fertility is conditional on a country's educational system. Fertility choice may also depend on

---

[1]In line with this, Manuelli and Seshadri (2009) find that the observed cross-country variation in fertility can be explained by a country's productivity and taxes. Along these lines, Jones and Schoonbroodt (2016) demonstrate that fertility is pro-cyclical.

budget constraints stemming from the costs of care for the aged (Morand, 1999) and the costs of childcare (Bar and Leukhina, 2010).

This literature provides useful insights into individuals' fertility choices. However, some researchers have highlighted that the existing models cannot fully explain the observed empirical patterns. For example, in a relevant study, based on empirical analysis, Doepke (2005) argues that the significant fall in net fertility rates cannot be solely attributed to the decline in infant and child mortality. Moreover, Jones et al. (2010) point out the existing fertility theories cannot fully explain the downward shift in the income-fertility relationship (observed in Figure 1). These arguments indicate that important factors that affect fertility choice are missing in the existing models.

Figure 1. *Structural shifts in the aggregate fertility-consumption relationship*
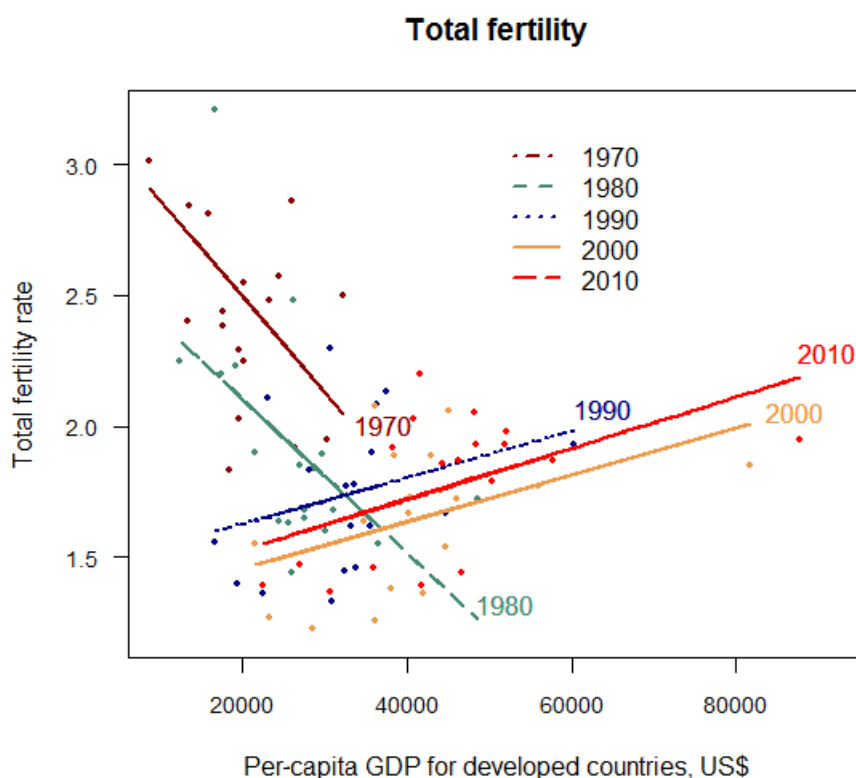
Per-capita real consumption in constant US$ as of 2010. Total fertility rates are for each country in the given year. The following countries are included: Austria, Australia, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Norway, Spain, Sweden, the United Kingdom, the United States, Portugal, and the Netherlands. Source of data: World Development Indicators, World Bank.

In light of these concerns, many researchers considered the possibility of individual fertility being influenced by factors other than the direct costs and benefits parents obtain from their children. How social norms related to fertility can explain the differences in demographic development paths across countries is demonstrated by Palivos (2001), Goto (2008), Munshi and Myaux (2006), and Bhattacharya and Chakraborty (2012). Similarly, Strulik (2004) uses the externalities stemming from the geographic location and state of the economy to explain child survival. The latter drives the investment in the quality of a child, and thus, affects the quality-quantity trade-off. Hazan and Zoabi (2005) argue that children's health is driven by income externalities (the average per-household income); thus, when the level of average income increases, it leads to improvements in a child's health, and consequently, raises the relative return to the quality of a child. The latter change results in a decline in fertility through the quality-quantity trade-off. Although, these studies demonstrate the importance of social norms in fertility choice, the literature still lacks a general framework that links fertility choice to social externalities stemming from consumption and human capital.

Another important aspect of the fertility evolution is the reversal of decline in fertility. Several recent empirical studies (Bongaarts and Sobotka, 2012; Day, 2016; Goldstein et al., 2009; Luci and Thévenon, 2011; Myrskylä et al., 2009) provide evidence corroborating the reversal of the decline in fertility. Notably, the existing theories, with the exception of a few studies, do not encompass a positive relationship between the fertility rate and high levels of income and consumption. Instead, the theories focused on explaining the decline in fertility without considering the possibility of a rebound of in the fertility rate. In this regard, the study by Hazan and Zoabi (2015) stands out by showing that individuals with human capital exceeding some threshold have more children. This study identifies the endogenous childcare cost as the driving factor leading to a rise in fertility of high-income women. In particular, Hazan and Zoabi (2015) show that women with high income can substitute the time cost of childcare by using market childcare services and thus, have more children. This mechanism can explain the U-shaped pattern of the fertility-income

relationship at the micro level. However, this U-shaped income-fertility relationship at the micro level is different from the reversal of average fertility (depicted in Figure 1). The main reason is that an increase in the fertility of high-income individuals can be offset by the reduced fertility of low-income individuals. Thus, how the average fertility increases together with the average income after exceeding some threshold level remains unexplained (shown in Figure 1).

To the best of our knowledge, only Day (2016) considers the reversal of the overall decline in fertility and suggests an explanation. Specifically, Day (2016) shows that a positive relationship between the average rate of fertility and per-capita income can be explained by increasing fertility when the majority of the population are skilled workers, and their wage rates grow more than proportionately to childcare costs. The latter condition holds only in the presence of public subsidies that increase the returns on childcare production. Thus, if this condition holds, the fertility rate would increase across all agents. However, maintaining increasing returns to labor may be a hard condition to satisfy in reality. Moreover, Day (2016) argues that fertility consistently declines with the level of human capital until everyone becomes a skilled worker. Therefore, the model cannot explain the observed U-shaped fertility rate at the micro level documented by Hazan and Zoabi (2015). It appears that accounting for only the direct economic effects on fertility (childcare costs, for example) cannot explain why the decline in fertility reverses at some high per-capita income levels not only for high-income individuals but also in terms of the aggregate averages.

In light of these inconsistencies between the theory and the empirical evidence, the purpose of this paper is to develop a model that overcomes these inconsistencies. In particular, we develop a model that incorporates the effect of the externalities caused by the average levels of consumption, fertility, and human capital in society on the individual fertility choice. Based on the model, we intend to ascertain whether these mechanisms can help us explain the observed patterns of aggregate and individual fertility.

The analysis based on the extended model demonstrates that the structural shift

in the income-fertility relationship and the reversal of the decline in fertility can be explained by the combined effect of the quantity-quality trade-off and social externalities. Specifically, consumption externalities affect fertility by increasing the marginal value of consumption compared to that of children. Additionally, by accounting for the external effect of fertility norms, this paper shows that the declining average fertility rate creates additional downward pressure on the fertility of individuals. As a consequence, the observed steepness and the shifts in the relationship between fertility rates and income levels (see Figure 1) can be attributed to changes in consumption and fertility norms. The results also demonstrate that when relative childcare costs are endogenous and depend on the human capital of parents (as in Day, 2016; Hazan and Zoabi, 2015), the fertility-human capital relationship at the individual level exhibits a U-shaped pattern. However, this mechanism cannot explain the reversal of the average fertility rate.

This paper explains the reversal of the decline in fertility by the nonlinear evolution of consumption externalities. In particular, if the externalities generated by average consumption are described as a nonlinear function, then the consumption externalities start fading after reaching some threshold level. With a lower external effect of the average consumption, the marginal utility of consumption also starts decreasing. Optimizing agents use the savings from reduced consumption spending to increase the quantity of children. This result is consistent with the empirical facts reflected in Figure 1.[2] From a broader perspective, the effects of average human capital on survival and education also contribute to the reversal of decline in fertility.

The contribution of this paper to the existing literature can be summarized as follows. First, this study introduces a new mechanism that captures the effect of externalities stemming from others' consumption and human capital in society on an individual's fertility choice. By accounting for these external effects on fertility choice, we generalize the existing models with social norms related to the number of

---

[2]The increase in fertility does not seem to be driven by the immigrant population's fertility, which may be higher than that of the local population. For example, Lanzieri (2013) indicates that in most high-income European countries, the immigrant population exhibited lower fertility than the local population.

children developed in Palivos (2001), Goto (2008), Munshi and Myaux (2006), and Bhattacharya and Chakraborty (2012). The extended model shows that the effect of social externalities can explain not only the cross-country differences in fertility rates but also the evolution of the relationship between fertility and income over time.

Second, our model reconciles the reversal of the decline in fertility at the micro and macro levels. The existence of reversals in fertility choice for high-income agents (as in Hazan and Zoabi, 2015) can lead to fertility changes in the same direction for other lower-income agents, too, as long as there are social externalities that transmit the effect of the average fertility changes to individual agents. Specifically, we show that the U-shaped fertility-income relationship at the micro level driven by endogenous childcare costs cannot explain the aggregate fertility reversal. We demonstrate that the aggregate fertility reversal is driven instead by social externalities.

Third, the theoretical propositions stemming from our model have been confirmed with data from the United States (US). The estimation results fully support the effects predicted by the theoretical model and provide strong supporting evidence that social externalities play a significant role in the evolution of fertility. Specifically, we find that the effect of average consumption on fertility is negative, while the effect of the average number of children on fertility is positive. The estimations demonstrate that the effect of average consumption on fertility is nonlinear; thus, with higher per-capita consumption levels, their negative effect on decline in fertility, which increases the marginal value of children compared to that of consumption, and leads to a rebound in the fertility rate. The results also show that the effect of the average human capital on fertility is conditional on the woman's type of education. The estimations based on the linear specification also show that the average human capital has a nonlinear effect on fertility. Similar to the average consumption, after the average human capital exceeds some threshold level, its overall effect of on fertility turns positive.

The rest of the paper is organized as follows. The next section presents the

background preliminaries based on the observed statistical patterns of the relationship between social externalities and fertility, as well as the relevant theoretical approaches. In Section 3, we describe the basic model with social externalities and present the analysis of its solution. In Section 4, we empirically test the analytical propositions obtained in Section 3. In Section 5, we conclude the paper. The proofs of the propositions are provided in the appendix.

2   Background

In this section, we discuss the theoretical and empirical rationale for the assumptions and features of the model to be developed in the next section.

2.1   Theoretical background

To explain why the relationship between income and the fertility rate is changing over time and why the decline in fertility is reversing in some high-income economies, we suggest that the effect of social externalities on fertility choice should be taken into account. For that purpose, we generalize the fertility choice models by incorporating social externalities. Specifically, we assume that the agents' preferences depend on the social norms in society related to consumption, the number of children (fertility), and the amount spent on education (the quality of children). Thus, it can be argued that an individual's fertility choice is influenced by the external effects rendered by the average consumption (the first factor), the average fertility rate (the second factor), and the average human capital (the third factor) in society.

Several studies have explored the link between the social norms associated with fertility and individual fertility choice. These studies (Bhattacharya and Chakraborty, 2012; Goto, 2008; Munshi and Myaux, 2006; Palivos, 2001) emphasize that the social norms regarding the number of children impact an individual's fertility choice. The link established by these studies has been used to explain the differences in patterns of fertility evolution across countries, the relationship between child mortality

and fertility, and the implications of fertility choice for inequality. However, these studies do not consider social norms as a factor behind the sharp decline in fertility, and they ignore the structural changes in the income-fertility relationship (as seen in Figure 1). Furthermore, these studies do not account for the external effects on fertility stemming from consumption and education spillovers and do not account for endogenous childcare costs.

The role of consumption externalities in capital accumulation and long-term growth has been discussed extensively in the literature.[3] These externalities are classified as "keeping up with the Joneses" (KUJ hereafter) and "catching up with the Joneses" (CUJ).[4] This study focuses only on KUJ-type preferences. Denoting the utility function by u and the levels of the agents' consumption and the average consumption in the economy in period t by c_t and $\bar{c}_t$, respectively, the positive KUJ effect stems from the contemporary average level of consumption, which is defined as $\frac{\partial^2 u}{\partial c_t \partial \bar{c}_t} > 0$ (see Chen et al., 2015, for details).[5] However, given the significance of the effect of KUJ preferences on inter-temporal consumption allocation and capital accumulation as highlighted in the literature, it appears natural to analyze whether KUJ-type preferences can help to explain the relationship between income and fertility. In addition, the fertility choice models with human capital (de la Croix and Doepke, 2003) assume that the average human capital (the third factor) exerts positive externalities on educational spending. Therefore, the average human capital of the adult generation in society affects the human capital accumulation of the young generation. Since the average human capital levels in society affect educational spending at the individual level, this effect can also be viewed as a type of KUJ preference.

---

[3]See Chen et al. (2015) for a literature review.

[4]The *CUJ* effect stems from the past average levels of consumption, and it is defined as $\frac{\partial^2 u}{\partial c_t \partial \bar{c}_{t-1}} > 0$ (see Abel, 1990; Ljungqvist and Uhlig, 2000).

[5]There is an alternative view, which argues that these consumption externalities can also be negative. The implications of the negative consumption externalities are presented in Ulph (2014).

2.2 Empirical background

Since we wish to ascertain whether there is supporting evidence for the relationship between individual fertility and social norms or externalities, while allowing for a U-shaped fertility relationship over the range of female education (as in Hazan and Zoabi, 2015), it is sensible to consider micro-level data. Specifically, we consider a dataset on fertility choice at the micro level for the US based on the National Opinion Research Center's General Social Survey. We construct line-plots to depict how the fertility rate is related to the average values of consumption and the number of children. As Figure 2 (left panel) indicates, there is a visible pattern of a positive association between the fertility rate and the average human capital. The relationship between the average consumption and the fertility rate (Figure 2, right panel) exhibits a pattern that is similar to the case with the average human capital. That is, the fertility of women bounces back after exceeding the threshold of the per-capita real consumption (in 2010 dollars) or of the average human capital. In both cases, the fertility rates of women with different education levels demonstrate structural dissimilarities in the rates' relationship with the externalities stemming from consumption and human capital. However, the norms related to fertility itself exert a positive effect on the individual fertility as Figure 3 (left panel) attests.

To see whether there is a similar U-shaped relationship between the fertility rates and the level of human capital as demonstrated by Hazan and Zoabi (2015), we also replicate their graph based on the dataset we use here. The patterns we obtain are somewhat similar to theirs in the sense there is either a rebound or a stabilization in the individual fertility of women with (some) college and advanced degrees (Figure 4). In addition, the data show that the childcare-cost differential across various education-level subgroups is consistently non-convergent, as was pointed out by Hazan and Zoabi (2015); see Figure 3, right panel. This implies that the childcare costs should be modeled as endogenous to the parents' human capital level.

Overall, the micro-level data for the US appear to support the relationship between these social externalities and fertility choice. In light of this, we develop a model that incorporates the described social externalities and endogenous childcare
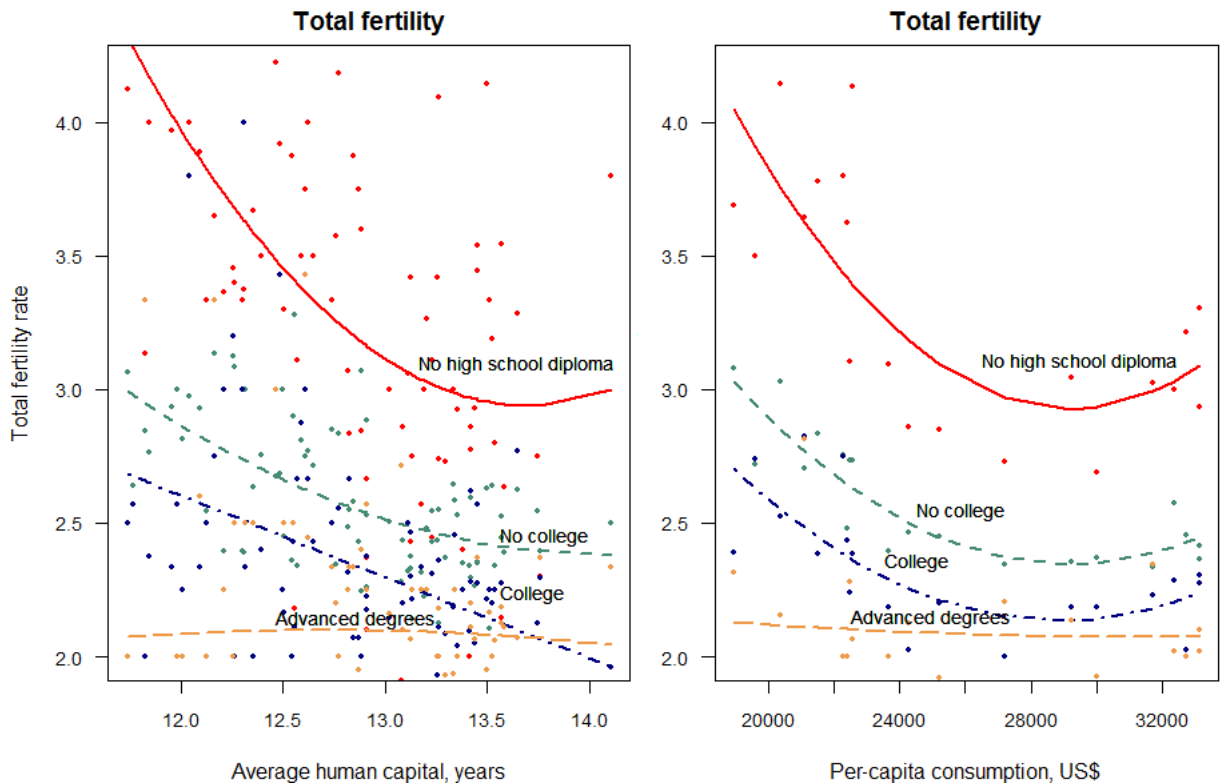
The dataset is obtained from the National Opinion Research Center's General Social Survey, http://www.norc.org/. The survey consists of a random sample of approximately 2,000 English-speaking persons 18 years of age or older living in non-institutional arrangements in the US. The survey data are not longitudinal. In this study, data from all of the available surveys are used (1983 to 2012).

costs into the agents' utility optimization problem and shows their implications for an individual's fertility choice.

3   Model

3.1   Outline of the model

To analyze the effect of social externalities on fertility choice, we set up an overlapping-generations model that incorporates the factors: consumption, fertility, and education through which social externalities affect an individual's optimization problem. In our model, agents live in two periods: childhood and adulthood. Adult agents are endowed with one unit of time that is inelastically spent on labor and child-rearing. Adult agents care about their consumption, $c_{it} \geq 0$, the number of children surviving to adulthood with the probability, π, and their human capital, $h_{i,t+1}$. This

Figure 3. *Fertility vs. the average fertility | Fertility vs. childcare costs (wage ratio)*
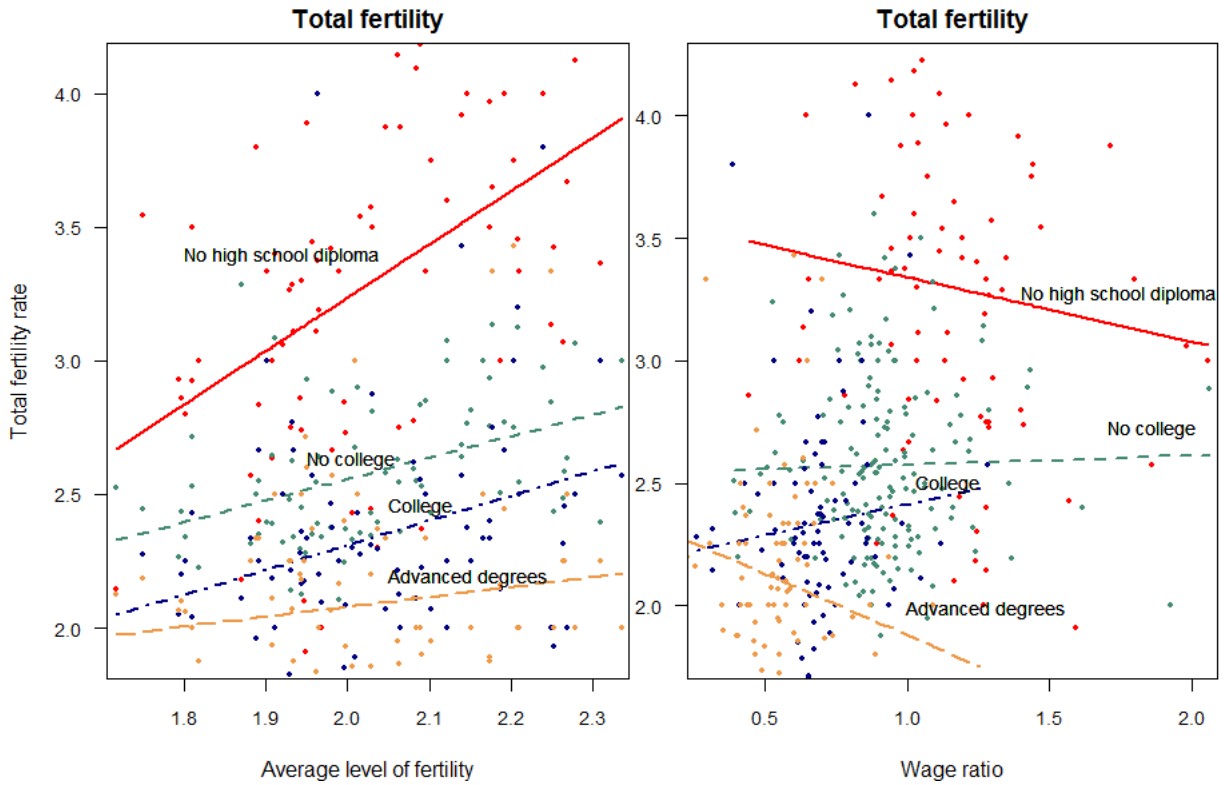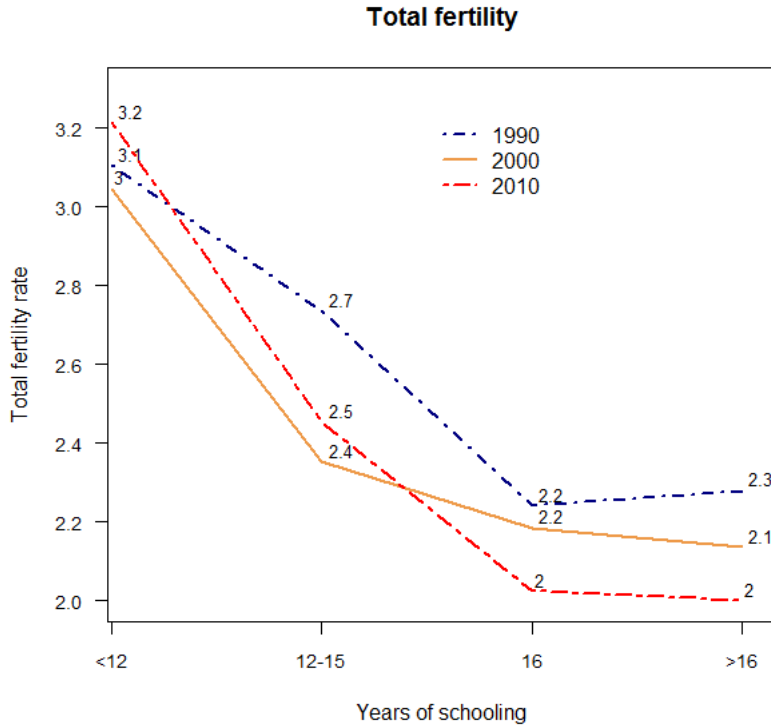
The dataset is obtained from the National Opinion Research Center's General Social Survey, http://www.norc.org/. In this study, data from 1983 to 2012 surveys are used. The wage ratio data are from Hazan and Zoabi (2015).

implies that the number of children born and alive after the infant age is given by n_{it}. That is, the the number of children includes only those children who are alive at the age for school. The probability of survival is defined similarly as Blackburn and Cipriani (2002) and is given as a function of the human capital of the parents and other external factors:

$$\pi(h_{it}) = \underline{\pi} + \frac{h_{it}}{\tilde{\pi} + h_{it}}, \tag{1}$$

where $0 < \tilde{\pi}$, $0 < \underline{\pi} < 1$; thus, $\frac{\partial \pi}{\partial h} > 0$, $\frac{\partial^2 \pi}{\partial h^2} < 0$, if $\pi < 1$. In addition, following Strulik (2004), it is assumed that $\underline{\pi}$ is determined externally to parents' decisions. It is reasonable to assume that this part of survival depends on the overall health care conditions driven by the average human capital. That is, $\underline{\pi}(\bar{h})$ such that $\frac{\partial \underline{\pi}(\bar{h})}{\partial \bar{h}} > 0$. However, this formulation of the probability of survival implies that for high human capital levels, it is possible that $\pi = 1$. In other words, either $\frac{\partial \pi}{\partial h} = 0 | h > argmax[\pi(h)]$ or $\frac{\partial \underline{\pi}}{\partial \bar{h}} = 0 | \bar{h} > argmax[\pi(\bar{h})]$. That is, a further increase in human capital does not have an effect on survival. This implies that the survival of children,

Figure 4. *Fertility by human capital levels*

Total fertility

The dataset is obtained from the National Opinion Research Center's General Social Survey, http://www.norc.org/. In this study, data from 1983 to 2012 surveys are used. The wage ratio data are from Hazan and Zoabi (2015).

in general, is given by the following:

$$\pi(h_{it}, \bar{h}_t) = \min\left(1, \underline{\pi}(\bar{h}) + \frac{h_{it}}{\tilde{\pi} + h_{it}}\right). \tag{2}$$

Childcare costs

Rearing each child requires time equal to $\bar{\tau}$. However, parents can substitute their own time with childcare services. Following Hazan and Zoabi (2015), we assume that only part of this childcare time comes from the parent, while the rest can be hired from the market for childcare services. Although we assume the same functional form as in Hazan and Zoabi (2015) for childcare services, we differ from them by relating the value of this function to the fixed time required to raise a child rather than the number of children. We build this rationale from the fact that in the models without childcare services, the cost of childcare is captured by the time parents spent looking after their children. This means that the time spent raising a child is fixed

13

by nature, so parents can cover that time only by mixing their own time with the time hired from the childcare services. It is assumed that the average human capital of childcare service workers is given by $\underline{h} \in (0, \bar{h}_t)$. To abstract from the problem of modeling the childcare labor market, it is assumed this value is determined exogenously.[6] Thus, we can write: $\bar{\tau} = \tau_o^\phi \tau_s^{1-\phi}$. The cost of childcare will then given by $CC = h_{it}\tau_o + \underline{h}\tau_s$. This implies that parents will minimize the costs subject to the production of the given services time:

$$\min_{\tau_s, \tau_o} CC = h_{it}\tau_o + \underline{h}\tau_s \tag{3}$$

s.t.

$$\bar{\tau} = f(\tau_o, \tau_s) = \tau_o^\phi \tau_s^{1-\phi}.$$

The optimality condition for this problem is given by:

$$\frac{f_{\tau_o}}{f_{\tau_s}} = \frac{h_{it}}{\underline{h}}.$$

By substituting for $f_{\tau_o} = \phi\tau_o^{\phi-1}\tau_s^{1-\phi}$ and $f_{\tau_s} = (1-\phi)\tau_o^\phi \tau_s^{-\phi}$, we find the following:

$$\frac{h_{it}}{\underline{h}} = \frac{\phi}{1-\phi}\frac{\tau_s}{\tau_o}. \tag{4}$$

From, $\bar{\tau} = \tau_o^\phi \tau_s^{1-\phi}$, it can be found that $\tau_s = \left(\frac{\bar{\tau}}{\tau_o^\phi}\right)^{\frac{1}{1-\phi}}$. By inserting the latter expression into (4), we obtain

$$\tau_o = \left(\frac{\phi\underline{h}}{(1-\phi)h_{it}}\right)\bar{\tau}. \tag{5}$$

Now, by using the equilibrium values for $\tau_o = \frac{\phi\bar{h}}{(1-\phi)h_{it}}\bar{\tau}$ and $\tau_s = \left(\frac{1-\phi}{\phi}\frac{h_{it}}{\underline{h}}\right)^{\frac{\phi}{1-\phi}}\bar{\tau}$, we re-write the total cost of child-rearing as

$$h_{it}\tau_o + \underline{h}\tau_s = \psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}}, \tag{6}$$

---

[6]It is possible that the level of human capital is related to the average human capital. However, this functional relationship may not be simple. Because in our model the main factor is how individual human capital is related to the childcare costs determined by $\underline{h}_t$, our specification, by capturing this link, is capable of mapping the human capital differential to the fertility differential. In view of this rationale, we abstract from modeling the human capital levels in the childcare sector.

where $\psi_1 \equiv \frac{\phi \underline{h} \bar{\tau}}{1-\phi}$ and $\psi_2 \equiv \left(\frac{1-\phi}{\phi}\right)^{\frac{\phi}{1-\phi}} \underline{h}^{\frac{1-2\phi}{\phi}} \bar{\tau}$.

It also can be easily verified that if the level of individual human capital is equal to or lower than $\underline{h}$, then (5) implies that $\tau_o = \bar{\tau}$. That is, agents with low-level human capital tend to spend their own time on child-rearing rather than hiring babysitters. However, the agents with high-level human capital find it optimal to hire babysitters and spend their time more on their work. This outcome is consistent with the facts and the models suggested by Hazan and Zoabi (2015) and Day (2016). Therefore, in the presence of childcare services, the time an agent spends working in the production sector is given as:

$$l_{it} = 1 - \tau_o n_{it}. \tag{7}$$

An utility function with social externalities

These social externalities are incorporated into the utility function of the agents based on the following intuition. The marginal utility of adult agents from consumption depends on the social preference levels for consumption measured by the average consumption level, $\bar{c}_t$. Similarly, the agents' utility that stems from the number of offspring also depends on the externalities created by the norms in society regarding the number of children. That is, similar to consumption, the average number of children per parent, $\bar{n}$, exerts an additional effect on the utility of an agent from the number of their own children[7].

Put another way, the social structure can affect the cost of having children, which stems from the fact that education is provided by schools (de la Croix and Doepke, 2003). This implies that the human capital evolution process depends not only on educational spending, e_{it}, and the parents' human capital, h_{it}, but also that the average human capital, $\bar{h}_t$, exerts positive externalities on human capital accumulation. Thus, similar to de la Croix and Doepke (2003), Fioroni (2010) and Omori (2009),the human capital of an agent evolves according to:

$$h_{i,t+1} = \left(\bar{h}_t^{1-\beta} h_{it}^{\beta}\right)^{1-\theta} e_{it}^{\theta}, \tag{8}$$

---

[7]We follow Palivos (2001) and Goto (2008) who employ the average fertility rate as the measure of the social norm in fertility preferences.

where $0 < \theta < 1$ and $0 < \beta < 1$[8].

Social externalities can be formally incorporated into the utility function of the agents by using the following common definitions (see Palivos, 2001). That is, for $x \in (\bar{c}, \bar{n}, \bar{h})$, the utility function satisfies $\frac{\partial u}{\partial x} > 0$; thus, positive spillovers stem from $\bar{c}, \bar{n}, \bar{h}$. and $\frac{\partial^2 u}{\partial c \partial x} > 0$, $\frac{\partial^2 u}{\partial n \partial x} > 0$, and $\frac{\partial^2 u}{\partial h \partial x} > 0$; thus, strategic complementarity stem from $\bar{c}$, $\bar{n}$, and $\bar{h}$. In light of this, we assume a paternalistic utility function in the constant elasticity of substitution (CES) form. This function incorporates the social externalities along with the standard choice variables, such as consumption, number of children, and education spending[9].

$$U_{it} = \gamma \left[\alpha (\bar{c}_t^\delta c_{it})^\rho + (1 - \alpha)(\pi_t n_{it} \bar{n}_t^\varepsilon \left(\bar{h}_t^{1-\beta} h_{it}^\beta \right)^{1-\theta} e_{it}^\theta)^\rho \right]^{\frac{1}{\rho}}. \tag{9}$$

The agents maximize their utility function subject to their budget constraints and the human capital evolution process.

It is assumed that the agents are heterogeneous in terms of their human capital levels. The probability distribution function (pdf) of human capital over the adult population is given by $f(h_{it})$. Under this setting, the effective labor of an agent is given as $h_{it} l_{it}$. The production function is specified as follows:

$$y_{it} = w h_{it} l_{it}. \tag{10}$$

Given that income is a linear function of labor, for simplicity, we normalize the wage rate, w, to 1. The budget constraint faced by an agent is then given as:

$$c_{it} = h_{it}[1 - \tau_o n_{it}] - (\tau_s \underline{h} + e_{it})n_{it}, \tag{11}$$

---

[8]Unlike the above studies, the focus of this study is not on determining the impact of educational spending on fertility; thus, for simplicity, it is assumed that human capital accumulation is possible only with non-zero spending on education.

[9]We follow Fioroni (2010) and de la Croix and Doepke (2003) in terms of conceptual modeling, but we use a different functional form. The reason for this choice is that the CES function is less restrictive than the Cobb-Douglas function employed by these authors, and in the current context, the CES form allows for better tractability. In addition, the externalities or norms can be modeled as the deviation from the average as in Bhattacharya and Chakraborty (2012), for example. However, this form also fits theses definitions of spillovers and complementaries, and analytically, it results in the same type of relationship.

where e_{it} is the amount of income spent on education for each child, and τ_o and τ_s are the time spent on childcare by the agent and the hired childcare services, respectively.

Because, according to (11), the level of consumption is depends the agent's level of human capital, the average level of consumption, $\bar{c}_t$, also depends to the average human capital, $\bar{h}_t$, given as:

$$\bar{h}_t = \int_{h_{min}}^{h_{max}} h_{it} f(h_{it}) dh_{it}. \tag{12}$$

The total population grows according to the function given as follows:

$$P_{t+1} = P_t \int_{h_{min}}^{h_{max}} n_{it} \pi_{it} f_t(h_{it}) dh_{it}. \tag{13}$$

The average fertility rate is determined by:

$$\bar{n}_t = \int_{h_{min}}^{h_{max}} n_{it} f_t(h_{it}) dh_{it}, \tag{14}$$

whereas the average consumption is determined by:

$$\bar{c}_t = \int_{h_{min}}^{h_{max}} c_{it} f_t(h_{it}) dh_{it}. \tag{15}$$

The distribution of human capital evolves as follows[10].

$$f_t(h_{it}) = \left[\frac{P_0}{P_t} \prod_{\theta=0}^{t} n_{i\tau} \right] f_0(h_{i0}). \tag{16}$$

Definition of Equilibrium

Given an initial distribution of human capital $f_0(h_0)$, and an initial population size P_0, and the level of human capital in the childcare sector $\underline{h}_t$, an equilibrium con-

---

[10]To obtain this formula, consider a change in the human capital distribution from period 0 to period 1. In period 0, the number of agents with human capital h_{i0} is found as the product of the share of this type of agent and the total population, $f_0(h_{i0})P_0$. In period 1, each type i agent will have n_{i1} children with h_{i1} human capital. Given that the total adult population in period 1 is P_1, the share of these type-i agents is found to be $f_1(h_{i1}) = \frac{[f_0(h_{i0})P_0]n_{i1}}{P_1}$. Using this recursive rule, one obtains the general rule given by equation (16).

sists of sequences of aggregate quantities $\{\bar{c}_t, \bar{h}_t, \bar{n}_t, P_{t+1}\}$, distributions $f_t(h_{it})$, and decision rules $\{c_{it}, n_{it}, e_{it}, h_{i,t+1}, \tau_{o,it}\}$ such that:

- the individual's decision rules $\{c_{it}, n_{it}, e_{it}, h_{i,t+1}, \tau_{o,it}\}$ maximize the utility subject to the constraints (11) and (8);

- markets clear by labor being distributed between childcare of own children and production (7), and in the goods market, the output is allocated between consumption, educational spending, and childcare services (11);

- the distribution of human capital evolves according to (16);

- aggregate variables $\bar{h}_t$, P_t, $\bar{n}_t$, and $\bar{c}_t$ are given by (12), (13), (14), and (15).

3.2 The agent's problem

Under this specified setting, the agent's problem is given by

$$\max_{c,n,e} U = \gamma \left[\alpha (\bar{c}_t^\delta c_{it})^\rho + (1-\alpha)(\bar{n}_t^\varepsilon \left(\bar{h}_t^{1-\beta} h_{it}^\beta \right)^{1-\theta} e_{it}^\theta \pi_t n_{it})^\rho \right]^{\frac{1}{\rho}}, \tag{17}$$

$$s.t. \, c_{it} = h_{it}[1 - \tau_o n_{it}] - (\tau_s \underline{h} + e_{it})n_{it}. \tag{18}$$

The agent's problem can be solved by maximizing the following Lagrangian:

$$L = \gamma \left[\alpha (\bar{c}_t^\delta c_{it})^\rho + (1-\alpha) \left(\left(\bar{h}_t^{1-\beta} h_{it}^\beta \right)^{1-\theta} e_{it}^\theta (\bar{n}_t^\varepsilon \pi_{it} n_{it}) \right)^\rho \right]^{\frac{1}{\rho}}$$
$$+ \lambda [h_{it}[1 - \tau_o n_{it}] - (\tau_s \underline{h} + e_{it})n_{it}, -c_{it}]. \tag{19}$$

Substituting for τ_o and τ_s from (5) for the childcare costs from (6), and solving for the optimal values of e_{it} and n_{it}, we obtain (see Appendix A1 for details):

$$e_t^* = \frac{\theta(\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}})}{(1-\theta)}, \tag{20}$$

18

$$n_{it}^* = \frac{h_i \left[\frac{\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}}}{(1-\theta)} \right]^{\frac{1}{\rho-1}}}{\left[\frac{(1-\alpha)}{\alpha} \bar{c}_t^{-\rho\delta} \bar{n}_t^{\rho\varepsilon} \left(\bar{h}_t^{1-\beta} h_t^\beta \right)^{\rho(1-\theta)} \left(\frac{\theta(\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}})}{(1-\theta)} \right)^{\theta\rho} \pi_t^\rho \right]^{\frac{1}{\rho-1}} + \left[\frac{\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}}}{1-\theta} \right]^{\frac{\rho}{\rho-1}}}.$$

(21)

The level of equilibrium consumption is determined using the budget constraint (18).

In the next section, theses equilibrium values for education spending and the fertility rate are analyzed.

3.3 Social externalities and fertility

Social externalities stemming from others' consumption

By analyzing the expression for the equilibrium fertility rate (21), the following proposition is stated.

Proposition 3.1 *For an agent solving the problem given by (17), an increase in the level of average consumption results in a reduction in fertility.*

Proof Using (21), it can be verified that $\frac{\partial n_{it}^*}{\partial \bar{c}_t} < 0$. See Appendix A2 for details.■

The intuition behind this result is simple. When the average consumption levels increase due to positive externalities, this change lifts the marginal utility of consumption. Given the budget constraint, the agents respond to this change by increasing their consumption and decreasing their fertility.

Social externalities stemming from fertility of others

By analyzing the equilibrium fertility rate given by (21), one can state the following proposition:

Proposition 3.2 *In the presence of social externalities in fertility ($\varepsilon > 0$), an increase in the average level of fertility, $\bar{n}$, raises the fertility rate of an agent.*

Proof Using (21), it can be verified that $\frac{\partial n_{it}^*}{\partial \bar{n}_t} > 0$. See Appendix A3 for details. ∎

This result indicates that the existence of externalities stemming from the average (socially desirable) level of fertility makes the effect of consumption externalities even stronger. This is because an increase in the average consumption reduces the average fertility, which creates additional externalities and exerts greater downward pressure on fertility. The complementarity of these externalities might be why in many countries fertility rates have been spiraling downward rapidly.

The effect of human capital on fertility

By analyzing the equilibrium value of educational spending given by (20), the following lemma is stated.

Lemma 3.3 *Spending on education increases with the level of the parents' human capital.*

Proof Taking the first-order derivative of (20) yields:

$$\frac{\partial e_{it}}{\partial h_{it}} = \frac{\theta\phi\psi_2 h_{it}^{\frac{\phi}{1-\phi}-1}}{(1-\theta)(1-\phi)} > 0. ∎$$

By analyzing the expression for the fertility rate (21), the following proposition is stated:

Proposition 3.4 *The effect of an increase in the parents' human capital on the fertility rate depends on whether the level of human capital is below or above a certain threshold value, $\tilde{h}_t$. It can be shown that the following conditions hold:*

$$\frac{\partial n_{it}^*}{\partial h_{it}} \begin{cases} < 0, \text{if } h_{it} < \tilde{h}_t, \\ = 0, \text{if } h_{it} = \tilde{h}_t, \\ > 0, \text{if } h_{it} > \tilde{h}_t. \end{cases}$$

Proof It can be verified by considering the comparative statics of (21) that $\frac{\partial n_{it}^*}{\partial h_{it}} \gtrless 0$. See Appendix A4 for details. ∎

This result shows that our model captures the U-shaped income-fertility relationship at the individual level as was demonstrated by Hazan and Zoabi (2015). Thus, inequality in human capital leads to inequality in fertility. However, this outcome cannot explain the rebound in the average fertility rate. For example, when the fertility of a fraction of the population declines with increasing human capital, whereas another fraction of the population may have a fertility rate that increases with the level of human capital. This possibility implies that one cannot ascertain the direction of the change in the overall fertility rate based on this outcome. To answer that question, it is more logical to consider the effect of the average human capital on an individual's fertility. The intuition for this rationale is as follows. The average human capital affects fertility not only through the cost of education but also through the effect of average human capital on average consumption and the externalities of fertility associated with average consumption. This aspect will be addressed in Section 3.4.

3.4 A reversal of the decline in fertility

Overall, the model specified can explain why the fertility rate is falling and why this decline has accelerated across countries. However, based on this model, we still cannot explain the observed reversal of the decline in fertility in high-income countries that they experienced after reaching some threshold levels of per-capita income. One possible explanation for this pattern may be that the consumption externalities are a concave function of the average consumption as the empirical evidence suggests (see Figures 1 and 2). That is, after reaching some threshold value, the positive effect of average consumption on the individual marginal utility appears to start falling. One way to model this type of nonlinear relationship is to formulate it as a concave function of the average consumption:

$$ v = v(\bar{c}_t) \in R^+, \quad \frac{\partial v}{\partial \bar{c}} \gtrless 0, \quad \frac{\partial^2 v}{\partial \bar{c}^2} < 0. \tag{22} $$

This implies that the marginal effect of consumption externalities initially rises with the rising average consumption, but after reaching $\bar{c}_m = argmax\{v\}$, it falls.

In light of this generalization, the utility function is re-stated as follows:

$$U_{it} = \gamma \left[\alpha(\nu^{\delta}c)^{\rho} + (1-\alpha)\left(n\bar{n}^{\varepsilon}\left(\bar{h}_t^{1-\beta}h_{it}^{\beta}\right)^{1-\theta}e^{\theta}\right)^{\rho}\right]^{\frac{1}{\rho}}. \tag{23}$$

Under this setting, we can analyze the comparative statics of n_{it} with regard to $\bar{h}_t$, and state the following proposition:

Proposition 3.5 *If the average consumption $\bar{c} > \bar{c}_m = arg[\nu(\bar{c})]$ is such that it implies $\frac{\partial\nu}{\partial\bar{c}} < 0$, then, given that $\frac{\partial\bar{c}}{\partial\bar{h}} > 0$ holds, the marginal effect of the average human capital on fertility becomes positive as long as $\bar{c} > \bar{c}_m$.*

Proof Given that and $\frac{\partial\nu}{\partial\bar{c}} < 0$ for $\bar{c} > \bar{c}_m = arg[\nu(\bar{c})]$, $\frac{\partial\bar{c}}{\partial\bar{h}} > 0$, and using (21), it can be verified that $\frac{\partial n_t}{\partial\bar{h}_t} > 0$ holds. See Appendix A5 for details of the proof.■

This result indicates that when income is above a certain threshold, fertility rises with income growth[11].

4   Empirical testing

Our theoretical analysis yields propositions regarding the effects of average consumption, fertility, and human capital levels on individual fertility choice. Moreover, if the external effects stemming from consumption are concave, this may explain the observed reversal of the decline in fertility. Since our theory implies that consumption and fertility externalities affect individual choices, the best way to test the predictions of the theory is to estimate the fertility rate by using micro-level data. We address this task by using the survey data from the General Social Survey conducted throughout the US by the National Opinion Research Center.

---

[11]The model we consider here is quite simple and thus, does not take into account other factors that may affect fertility, along with income and the externalities discussed above. Therefore, one cannot tell how the upper bound on fertility will be determined based on this model. In general, it is reasonable to expect that the upper bound can be determined by natural fertility limits if there is no other factor that would constrain it; it can also be affected by other factors, such as environmental degradation and congestion that stem from overpopulation and production. To answer this question, one needs to consider a model that incorporates the environment and its impact on fertility; therefore, this question is beyond the scope of this study.

4.1 Empirical model

Taking into account (22), we re-write (21) as

$$
n_t^* = \cfrac{1}{\left[\left[\frac{(1-\alpha)}{\alpha} v_t^{-\rho\delta} \bar{n}_t^{\rho\varepsilon} \left(\bar{h}_t^{1-\beta} \right)^{\rho(1-\theta)} h_t^{\rho[\beta(1-\theta)-1]-1} \left(\frac{\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}}}{1-\theta} \right)^{\theta\rho-1} \theta^\theta \rho \, \pi_t^\rho \right]^{\frac{1}{\rho-1}} + \left[\frac{\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}}}{(1-\theta)h_{it}} \right] \right]}.
$$

(24)

We linearize equation (24) approximately by taking logs and obtain a reduced form equation as follows[12].

$$
\ln n_{it} \approx b_0 + b_1 \ln h_{it} + b_2 \ln \bar{h}_t + b_3 \ln \bar{n}_t + b_4 \ln v_t + b_5 \ln \psi_t.
$$

(25)

In this approximation, we simplify the cost of childcare by denoting it by a catch-all variable ψ.

To formulate the empirical model to estimate the relationships between the fertility rate and social externalities, we state the consumption externalities in a more specific form than we assumed so far. We specify the consumption externalities as a concave function given by:

$$
v = \chi^{a\bar{c}-b\bar{c}^2},
$$

where χ, a, and b are parameters. It can be verified that this function satisfies the required conditions $\frac{\partial v}{\partial \bar{c}} \gtrless 0$, $\frac{\partial^2 v}{\partial \bar{c}^2} < 0$; thus, it can be used as a specific form of the externalities function. Following Hazan and Zoabi (2015), we use the ratio of the average wage rate of those who worked in the childcare industry for a given region and year to the overall average wage rate for the same region and year as a proxy for childcare costs. Therefore, instead of the log of ψ_t we use the log of the wage ratio, $\ln wr_t$. Incorporating this specific functional form and a vector of the control variables (**X**), we re-write the general empirical model for the fertility rate (25) as

---

[12]We assume that the second term of the denominator of (24) relative to the first term of the denominator is small enough to disregard in the linearization.

follows:

$$\ln n_{it} = a_0 + \beta \mathbf{X} + a_1 \ln h_{it} + a_2 \ln \bar{h}_t + a_3 \ln wr_t + a_4 \ln \bar{n}_t + a_5 \bar{c}_t + a_6 \bar{c}^2 + u_{it}. \quad (26)$$

In light of the analytical findings presented above, we expect the following signs of the coefficients given in (26): $a_1 < 0$, $a_2 < 0$, $a_3 < 0$, $a_4 > 0$, $a_5 < 0$ and $a_6 > 0$. In other words, we expect that the level of an individual's human capital and the average human capital have a negative impact on fertility[13]. The level of the average consumption reduces fertility, whereas the squared value of the average consumption is expected to have a positive effect on fertility. The social fertility norms captured by the average fertility rate are expected to have a positive impact on individual fertility choice. The cost of childcare captured by the relative wage rate of the childcare workers is naturally expected to have a negative effect on fertility.

In addition to the variables of interest, following the literature and based on our preliminary statistical analysis, we added the following variables as control variables: age, race, religion, and education subgroup (high school, college, etc.).

The Reflection Problem

In our attempt to estimate the above-specified recession, we face an estimation challenge called 'the reflection problem'. The reflection problem first described by Manski (1993), arises when we try to infer whether the average behavior of a group affects the behavior of the individuals in that group. A more extended discussion of this problem is given in Brock and Durlauf (2001) and Blume et al. (2011).

Manski (1993) specified that each agent is characterized by a value for $(y, x, z, u) \in R^1 \times R^J \times R^K \times R^1$. y is a scaler measure (fertility rate), x are attributes characterizing an individual's reference group (an agent's region, race, religion), and (z, u) are attribute that directly affect y (socioeconomic status-consumption, human capital). The parameters of such regressions are not identified if any of the following conditions hold:

---

[13]In this specification, we ignore the possible nonlinear effects stemming from the average human capital and an individual's human capital. We revisit this aspect while considering the linear specification of the empirical model in Subsection 4.3.1.

- z is a function of x

- $E(z|x)$ does not vary with x

- $E(z|x)$ is a linear function of x.

4.2 Data and estimation

In the estimations we use the data obtained from the website of the National Opinion Research Center[14]. The data were collected in the General Social Survey conducted throughout the US. The survey was conducted annually most years from 1972 to 1994, then biannually since 1996. It consists of a random sample of approximately 2,000 English-speaking persons 18 years of age or older living in non-institutional settings in the US. The survey data are not longitudinal. We select only those women who fall into the age group between 35 and 54 years[15]. In this regard, we follow Sander (1992) who argued that younger women should not be selected because a high proportion may not have completed their education, and thus, their potential fertility rates have not been realized yet. Evidently, the vast majority of women in the US aged 35 to 50 have achieved their potential fertility rates (Monte and Ellis, 2012). We can demonstrate that between 35 and 54 years of age the total fertility stabilizes based on a simple graph that relates the average number of children for each age (see Figure 4 in Appendix B1).

The other variables are as follows: The average number of children is computed as the average of all children born each year across all regions of the US covered in the survey, the average education is computed as the average for each year, and the real consumption per capita (the average consumption) in the US is obtained from the website of the Federal Reserve Economic Data. This variable is measured in chained 2010 dollars, and it is seasonally adjusted[16]. Following Hazan and Zoabi (2015), we use as a proxy for childcare costs the wage ratio data used in their study. Given the availability of data for the latter variable, we restrict ourselves to the time

---

[14]Accessed on 17 March 2016, http://www.norc.org/

[15]We also tried using a dataset that included women age between 25 and 50 years old as in Hazan and Zoabi (2015). The results (except the effect of age) were not different from the results obtained for women age between 35 and 54.

[16]Accessed 17 March 2016, https://research.stlouisfed.org/fred2/

period between 1983 and 2012. We aggregate their variable from the format of state and year to the format given by US regions (West, Northeast, Midwest, and South) and year. Following Sander (1992), we include other control variables, such as age, race, religion, education group, region at age of sixteen (relative to the South), and the type of residence (relative to big cities with a population of more than 250,000) at age 16. The descriptive statistics of the data is given in Table 1.

The fertility rates are estimated using ordinary least squares (OLS) and two-stage least squares (TSLS) methods. In the TSLS estimates, the possible endogeneity of a woman's educational level is addressed by instrumenting it with her father's and mother's educational levels. A Durbin-Wu-Hausman test on the regressor endogeneity fails to reject the hypothesis that women's education is endogenous. A Hansen's test shows that the overidentification restrictions hold. A test for weak instruments rejects the null hypothesis of weak instruments. Not only is the possible endogeneity of women's education rejected, but also we find almost no statistically significant difference between the OLS and TSLS estimations. For this reason, we report only the OLS estimations.

4.3 Results

Table 2 shows the estimation results for (26). The highly statistically significant negative coefficient for real consumption per capita (PCC) indicates that fertility declines with growth in real consumption per capita. Thus, the decline in fertility in the US can be partially attributed to the effect of consumption externalities. Moreover, the positive sign on the squared consumption indicates that the effect of consumption externalities on fertility is concave (thus the fertility rate is U-shaped in real consumption per capita). Therefore, at higher levels of the average consumption, its effect on individual consumption, and thus, on fertility choice weakens. This result is in line with our theoretical explanation for the reversal in the fertility rate observed in the data. The effect of an increase in real consumption per capita on the fertility rate changes as we move from lower to higher levels of real consumption per capita. When real consumption per capita reaches the range of $22-28

26

Table 1: Descriptive statistics

Variable	Mean	Standard deviation
	(1)	(2)
All children born	2.54	1.34
Education (years)	13.38	2.63
Ave. education	12.99	0.52
age	43.94	5.72
Ave. no. children	2.01	1.14
Wage ratio	0.87	0.29
Black	18.48%	38.81%
Catholic	23.20%	42.21%
Protestant	62.71%	48.36%
Advanced degrees	10.95%	31.22%
College	13.56%	34.23%
No college	61.91%	46.56%
Midwest	21.35%	40.98%
Northeast	26.87%	44.33%
West	23.53%	42.42%
Farm	10.24%	30.31%
Other rural	14.94%	35.65%
Small city	16.61%	37.22%
Town	30.98%	46.24%
Sample size	6970	

thousand in 2010 dollars, the effect of consumption externalities on fertility changes from negative to positive.

The coefficient of the average number of children has the expected positive sign and is statistically significant, which implies that the norms about fertility in a society exert an external effect on individual fertility choices, and thus amplifies the decline and rise. The level of individual human capital has a negative impact on fertility[17]. The overall effect of the average education is positive and is conditional on the type of education (see model 2 in Table 2). The specification with the relative education and controls for the type of education (high school, college) suggests that the inequality in terms of human capital accumulation contributes to the fertility rate dispersion. In addition, the results indicate that not only the number of years of schooling is important but also accounting for the qualitative jumps that stem from the types of education (advanced degree, college, high school) is important in

---

[17]Later, when we consider the linear specification we find that the effect of individual human capital may be nonlinear.

Table 2: Estimates of all children born to women aged 35 to 54: log-log form.

	(1)	(2)
log(educ)	-0.257***	-0.256***
log(av_educ)	-0.059	-2.089**
log(age)	0.370***	0.367***
Catholic	0.086***	0.087***
Protestant	0.058**	0.058**
PCC	-0.109***	-0.095***
PCC^2	0.002***	0.002***
log(av_kids)	0.375**	0.392***
Advanced degree	-0.179***	-8.140***
College	-0.134***	-3.182
HS_Some college	-0.111***	-6.268***
log(wr)	-0.013	-0.032
Black	0.081***	0.110***
log(wr)$\times$ Black		0.173***
Midwest	-0.024	-0.023
Northeast	-0.042*	-0.040*
West	-0.064***	-0.064***
Farm	0.038◇	
Other rural	0.011	0.011
Small city	0.033	0.033◇
Town	0.017	0.018
log(ave_educ)$\times$ Advanced degrees		3.207***
log(ave_educ)$\times$ College		1.233
log(ave_educ)$\times$ HS_Some college		2.572***
PCC$\times$ Advanced degrees		-0.010
PCC$\times$ College		-0.003
PCC$\times$ HS_Some college		-0.016*
Intercept	1.542◇	6.390***
Ad. R^2	0.078	0.082
F statistic	30.51***	24.19***

◇ Significant at the 10% level
* Significant at the 5% level
** Significant at the 1% level
*** Significant at the 0.1% level

determining the effect of education on fertility. A similar discontinuous effect of education is found for the interactions between the average consumption and the type of education. In particular, the results suggest that the effect of consumption externalities is stronger for women with a high school diploma or some college education compared to other women.

The estimates also confirm that the cost of childcare has a negative effect on fertility. The interaction term between (*Black*) and the childcare cost (*wr*) is positive

suggesting that the overall effect of the childcare cost is positive for a representative of the black population. One reason for this outcome might be that the childcare cost captured by the relative wages may also indicative the relative incomes of this subgroup of the population; thus, the interaction term captures the income effect on fertility, in this case. This also implies that the fertility of the non-black population is driven more strongly by childcare costs.

Overall, the results demonstrate that social externalities are statistically highly significant and important factors that drive the evolution of fertility choice in the US. Moreover, the average consumption affects an individual's fertility in a nonlinear fashion and in line with the reversal of the decline in fertility observed in the US and in and other high-income economies.

4.3.1 Additional estimations based on a linear specification

We test a linear specification of the fertility equation similar to that suggested by Sander (1992). This specification may be a less precise approximation of the underlying relationship between fertility choice and the other variables considered in the model. However, if the marginal effect of the average consumption, included in the quadratic form in the log-log specification, is robust, then one should also expect similar results in the linear specification. The original Sander specification (column 1 in Table 3) shows that there is a statistically significant time effect that when we take into account the externalities becomes statistically insignificant. This confirms that the observed structural shifts in the relationship between income and fertility are driven by the social effects. In addition, a linear specification allows us to consider other forms of nonlinearity that may exist in fertility choice. For example, our theoretical model shows that the average human capital has direct effects on fertility through the effectiveness of education and has indirect effects on fertility through the average consumption. To see whether the convexity of the fertility-income relationship is also driven by the average human capital, we include $\bar{h}_t^2$ into

Table 3: Estimates of all children born to women age 35 to 54: linear form.

	(1)	(2)	(3)
educ	-0.104***	-0.168**	-0.169***
educ^2		0.004◇	0.044◇
ave_educ		-3.586*	-3.483*
ave_educ^2		0.139*	0.116*
age	0.026***	0.025***	0.025***
Catholic	0.229***	0.243***	0.247***
Protestant	0.126***	0.141**	0.139**
PCC		-0.268***	-0.254***
PCC^2		0.005***	0.005***
ave_kids		0.567***	0.576***
Advanced degree		-0.529***	-8.513***
College		-0.433***	-4.682*
HS_Some college		-0.377***	-6.800***
Wage ratio (wr)		-0.115	-0.182*
Black	0.335***	0.324***	-0.280*
Wage ratio (wr) × Black			0.670***
Midwest	-0.083◇	-0.066	-0.068
Northeast	-0.076◇	-0.170***	-0.167***
West	-0.138**	-0.169***	-0.178***
Farm	0.142*	0.127*	0.199*
Other rural	0.029	0.010	0.011
Small city	0.056	0.051	0.049
Town	0.021	0.017	0.019
Year	-0.019***	-0.008	
ave_educ× Advanced degrees			0.649***
ave_educ× College			0.348◇
ave_educ× HS_Some college			0.570***
PCC× Advanced degrees			-0.015
PCC× College			-0.007
PCC× HS_Some college			-0.034*
Intercept	39.60***	45.25*	31.06***
Ad. R^2	0.89	0.107	0.11
F statistic	53.88 ***	37.29***	31.57***

◇ Significant at 10% level
* Significant at 5% level
** Significant at 1% level
*** Significant at 0.1% level

the regression equation. Thus, we have the following specification:

$$n_{it} = \alpha + \beta \mathbf{X} + \gamma_1 h_{it} + \gamma_2 \bar{h}_t + \gamma_3 \bar{h}_t^2 + \gamma_3 \bar{c}_t + \gamma_5 \bar{c}_t^2 + \gamma_6 \bar{n}_t + \gamma_7 wr_t + u_t.$$

The results obtained (Table 3) are not different in principle from the above speci-

fication in the log form (Table 2). In addition, we find that the average human capital also contributes to the reversal of the decline in fertility as the results demonstrate the quadratic term of the average human capital is statistically significant across different specifications (although not strong). We also test whether the nonlinearity of the fertility-income relationship is driven by the human capital of the agents by adding the squared values of the human capital of the agents, h_{it}^2. The results indicate that the level of individual human capital affects individual fertility in a nonlinear manner (see Table 3). This finding confirms our Proposition 3.4 and is in line with Hazan and Zoabi (2015) results. The new point we make is that the nonlinear effect of individual human capital on individual fertility is detected even after we control for the average consumption and human capital, as well as the relative cost of childcare and types of education. The effect of the childcare cost is negative as expected, and its statistical significance is stronger than in the log specification. In general, the results for the linear model are in line with the log-log specification results and confirm the importance of the social externalities for fertility choice.

5   Conclusion

The contribution of this paper to the literature can be summarized as follows. The model developed in this paper explains the following patterns in aggregate data that were inconsistent with the existing theories: (1) The observed decline in fertility is too steep to be fully explained by income growth only, (2) the relationship between income and fertility is shifting over time, and (3) the decline in the average fertility rate reverses at high levels of income. In particular, we extend the fertility choice model by simultaneously accounting for social externalities in consumption, fertility, average human capital, and endogenous childcare costs.

When social externalities are taken into account, the marginal value of consumption increases with the average level of consumption. The optimizing agents respond to an increase in the average level of consumption by reducing their fertility rate and increasing their consumption. Therefore, accounting for social externalities adds another channel, through which rising average income and the associated

higher per-capita consumption can additionally depress fertility. This suggests an insight into why the observed decline in fertility has been greater than the decline in fertility that would have been caused solely by the decrease in child mortality and the increase in income levels (Doepke, 2005). By incorporating the external effect of others' fertility choice into individual preferences, we demonstrate that the average fertility rate contributes to the observed structural shifts in the relationship between the fertility rate and the income level (see Figure 1). Finally, assuming that the externalities exerted by the average consumption are a nonlinear function, we find that the decline in fertility can be reversed at high levels of per-capita income. This reversal occurs due to the diminishing marginal utility of consumption externalities. This result explains the observed reversal of the decline in fertility that occurred in some high-income countries in recent years (see Figure 1).

In addition, by accounting for endogenous childcare costs, it has been demonstrated that the inequality in terms of human capital not only leads to a dispersion in fertility rates but may also result in a U-shaped fertility-human capital relationship at the individual level. We show that this channel cannot robustly explain the rebound of the average fertility rate observed in developed economies recently, as it is based on the income effect that favors only the rich. The overall movements in the fertility rate are caused by factors that affect all the agents, or at least the majority of them. Our results indicate social externalities play that role in fertility choice.

By estimating the number of children born to women age 35 to 54 in the US, we have obtained strong evidence that the fertility rate has been affected by real consumption per capita and the average number of children. Moreover, the estimations show the effect of consumption on fertility changes as we move from lower to higher levels of real consumption per capita. When real consumption per capita is in the range of $22-28 thousand, this effect becomes positive. Our results also indicate that the effect of human capital on fertility is not uniform, and the effect depends on the relative position of the individual's educational level. That is, the impact of the average education level is also conditional on an individual's educational level, and can be either positive or negative depending on the type of education.

Overall, this paper suggests new insights into fertility choice and enhances our understanding of its evolution, by simultaneously accounting for social externalities in consumption, fertility, average human capital, and endogenous childcare costs.

Appendix

A1. Solution of the model in Subsection 3.2

From here on, for the clarity of exposition, we drop the i indexes. The agent's optimization problem can be solved by maximizing the following Lagrangian:

$$L = \gamma \left[\alpha(\bar{c}_t^\delta c_{it})^\rho + (1-\alpha)(\bar{n}_t^\varepsilon \left(\bar{h}_t^{1-\beta} h_{it}^\beta \right)^{1-\theta} e_{it}^\theta \pi_t n_{it})^\rho \right]^{\frac{1}{\rho}} + \lambda[h_{it}[1 - \tau_o n_{it}] - (\tau_s \underline{h}_t + e_{it})n_{it} - c_{it}]$$

(27)

The first-order conditions are written as follows:

$$\frac{\partial L}{\partial c} = \frac{\gamma}{\rho} \left[\alpha(\bar{c}_t^\delta c_{it})^\rho + (1-\alpha)(\bar{n}_t^\varepsilon \left(\bar{h}_t^{1-\beta} h_{it}^\beta \right)^{1-\theta} e_{it}^\theta \pi_t n_{it})^\rho \right]^{\frac{1-\rho}{\rho}} \left(\alpha\rho\bar{c}_t^{\delta\rho} c_{it}^{\rho-1} \right) - \lambda = 0.$$

(28)

$$\frac{\partial L}{\partial n} = \frac{\gamma}{\rho} \left[\alpha(\bar{c}_t^\delta c_{it})^\rho + (1-\alpha)(\bar{n}_t^\varepsilon \left(\bar{h}_t^{1-\beta} h_{it}^\beta \right)^{1-\theta} e_{it}^\theta \pi_t n_{it})^\rho \right]^{\frac{1-\rho}{\rho}} \times$$
$$\left((1-\alpha)\rho n_{it}^{\rho-1}(\bar{n}_t^\varepsilon \left(\bar{h}_t^{1-\beta} h_{it}^\beta \right)^{1-\theta} \pi_t e_{it}^\theta)^\rho \right) - \lambda(h_t \tau_o + \underline{h}_t \tau_s + e_{it}) = 0.$$

(29)

$$\frac{\partial L}{\partial e} = \frac{\gamma}{\rho} \left[\alpha(\bar{c}_t^\delta c_{it})^\rho + (1-\alpha)(\bar{n}_t^\varepsilon \left(\bar{h}_{it}^{1-\beta} h_{it}^\beta \right)^{1-\theta} e_{it}^\theta \pi_t n_{it})^\rho \right]^{\frac{1-\rho}{\rho}} \times$$
$$\left((1-\alpha)\rho\theta e_{it}^{\theta\rho-1}(\bar{n}_t^\varepsilon \left(\bar{h}_{it}^{1-\beta} h_{it}^\beta \right)^{1-\theta} \pi_t n_{it})^\rho \right) - \lambda n_{it} = 0.$$

(30)

Using (28) and (29), we write

$$(1-\alpha)n_{it}^{\rho-1}(\bar{n}_t^\varepsilon \left(\bar{h}_t^{1-\beta} h_{it}^\beta \right)^{1-\theta} \pi_t e_{it}^\theta)^\rho = (h_t \tau_o + \underline{h}_t \tau_s + e_{it})(\alpha\bar{c}_t^{\delta\rho} c_{it}^{\rho-1}).$$

Solving for n_{it}, we obtain:

$$n_{it} = \left(\frac{(h_{it}\tau_o + \underline{h}_t\tau_s + e_{it})(\alpha \bar{c}_t^{\delta\rho})}{(1-\alpha)[\bar{n}_t^\varepsilon \left(\bar{h}_t^{1-\beta} h_{it}^\beta \right)^{1-\theta} \pi_t e_{it}^\theta]^\rho} \right)^{\frac{1}{\rho-1}} c_{it}. \tag{31}$$

Using (29) and (30), we write the following:

$$\frac{(\bar{n}_t^\varepsilon \left(\bar{h}_t^{1-\beta} h_{it}^\beta \right)^{1-\theta} e_{it}^\theta \pi_t n_{it})^\rho}{n_{it}(h_{it}\tau_o + \underline{h}_t\tau_s + e_{it})} = \frac{\theta(\bar{n}_t^\varepsilon \left(\bar{h}_t^{1-\beta} h_{it}^\beta \right)^{1-\theta} e_{it}^\theta \pi_t n_{it})^\rho}{n_{it} e_{it}}.$$

Solving the latter equation for e_{it}, we obtain:

$$e_{it}^* = \frac{\theta(h_{it}\tau_o + \underline{h}_t\tau_s)}{(1-\theta)}. \tag{32}$$

Given that the labor supply is inelastic and the utility function is concave, the budget constraint is binding:

$$c_{it} = h_{it}(1 - \tau_o n_{it}) - (\underline{h}_t\tau_s + e_{it}^*)n_{it}. \tag{33}$$

Solving (33) together with (31) yields the equilibrium value of the fertility rate:

$$n_{it}^* = \frac{h_{it}\left(h_{it}\tau_o + \underline{h}_t\tau_s + e_{it} \right)\alpha\bar{c}_t^{\rho\delta}\right)^{\frac{1}{\rho-1}}}{\left[(1-\alpha)\left(\bar{n}_t^\varepsilon \left(\bar{h}_t^{1-\beta} h_{it}^\beta \right)^{1-\theta} \pi_t e_{it}^\theta \right)^\rho \right]^{\frac{1}{\rho-1}} + \left[(h_{it}\tau_o + \underline{h}_t\tau_s + e_{it})^\rho \alpha\bar{c}_t^{\rho\delta} \right]^{\frac{1}{\rho-1}}}. \tag{34}$$

Recalling the equilibrium values for $\tau_o = \frac{\phi\bar{h}_t}{(1-\phi)h_{it}}\bar{\tau}$ and $\tau_s = \left(\frac{1-\phi}{\phi} \frac{h_{it}}{\underline{h}_t} \right)^{\frac{\phi}{1-\phi}} \bar{\tau}$, we re-write $h_{it}\tau_o + \underline{h}_t\tau_s = \psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}}$. Here, $\psi_1 \equiv \frac{\phi\bar{\tau}\bar{h}_t}{1-\phi}$ and $\psi_2 \equiv \left(\frac{1-\phi}{\phi} \right)^{\frac{\phi}{1-\phi}} \underline{h}_t^{\frac{1-2\phi}{\phi}} \bar{\tau}$.

$$n_{it}^* = \cfrac{\left[\cfrac{\psi_1 h_{it}^{\rho-1}+\psi_2 h_{it}^{\frac{1-\phi}{\phi}+\rho-1}}{(1-\theta)}\right]^{\frac{1}{\rho-1}}}{\left[\cfrac{(1-\alpha)}{\alpha}\bar{c}_t^{-\rho\delta}\bar{n}_t^{\rho\varepsilon}\left(\bar{h}_t^{1-\beta}h_{it}^{\beta}\right)^{\rho(1-\theta)}\left(\cfrac{\theta(\psi_1+\psi_2 h_{it}^{\frac{\phi}{1-\phi}})}{(1-\theta)}\right)^{\theta\rho}\pi_t^{\rho}\right]^{\frac{1}{\rho-1}}+\left[\cfrac{\psi_1+\psi_2 h_{it}^{\frac{\phi}{1-\phi}}}{1-\theta}\right]^{\frac{\rho}{\rho-1}}}.$$

(35)

A2. Proof of Proposition 3.1

Proposition 3.1 can be verified by the following. Take the first-order derivative of (35) and obtain:

$$\frac{\partial n^*}{\partial \bar{c}}=\frac{\delta\rho}{(\rho-1)}\times$$

$$\cfrac{\left(\cfrac{\psi_1 h_{it}^{\rho-1}+\psi_2 h_{it}^{\frac{1-\phi}{\phi}+\rho-1}}{(1-\theta)}\right)^{\frac{1}{\rho-1}}\left[\cfrac{(1-\alpha)}{\alpha}\bar{n}_t^{\rho\varepsilon}\left(\bar{h}_t^{1-\beta}h_{it}^{\beta}\right)^{\rho(1-\theta)}\left(\cfrac{\theta(\psi_1+\psi_2 h_{it}^{\frac{\phi}{1-\phi}})}{(1-\theta)}\right)^{\theta\rho}\pi_t^{\rho}\right]^{\frac{1}{\rho-1}}\bar{c}_t^{-\frac{\rho\delta}{\rho-1}-1}}{\left(\left[\cfrac{(1-\alpha)}{\alpha}\bar{c}_t^{-\rho\delta}\bar{n}_t^{\rho\varepsilon}\left(\bar{h}_t^{1-\beta}h_{it}^{\beta}\right)^{\rho(1-\theta)}\left(\cfrac{\theta(\psi_1+\psi_2 h_{it}^{\frac{\phi}{1-\phi}})}{(1-\theta)}\right)^{\theta\rho}\pi_t^{\rho}\right]^{\frac{1}{\rho-1}}+\left[\cfrac{\psi_1+\psi_2 h_{it}^{\frac{\phi}{1-\phi}}}{1-\theta}\right]^{\frac{1}{\rho-1}}\right)^2}.$$

As $\frac{\delta\rho}{\rho-1} < 0$ due to $\rho < 1$, while the other terms are positive, $\frac{\partial n^*}{\partial \bar{c}} < 0$ holds.

A3. Proof of Proposition 3.2

To ascertain the effect of average fertility on an individual's fertility, we consider $\frac{\partial n^*}{\partial \bar{n}}$ using (35):

$$\frac{\partial n^*}{\partial \bar{n}} = -\frac{\varepsilon \rho}{(\rho - 1)} \times$$

$$\frac{\left(\frac{\psi_1 h_{it}^{\rho-1} + \psi_2 h_{it}^{\frac{1-\phi}{\phi}+\rho-1}}{(1-\theta)}\right)^{\frac{1}{\rho-1}} \left[\frac{(1-\alpha)}{\alpha} \bar{c}_t^{-\delta\rho} \left(\bar{h}_t^{1-\beta} h_{it}^{\beta}\right)^{\rho(1-\theta)} \left(\frac{\theta(\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}})}{(1-\theta)}\right)^{\theta\rho} \pi_t^{\rho}\right]^{\frac{1}{\rho-1}} \bar{n}_t^{-\frac{\rho\varepsilon}{\rho-1}-1}}{\left(\left[\frac{(1-\alpha)}{\alpha} \bar{c}_t^{-\rho\delta} \bar{n}_t^{\rho\varepsilon} \left(\bar{h}_t^{1-\beta} h_{it}^{\beta}\right)^{\rho(1-\theta)} \left(\frac{\theta(\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}})}{(1-\theta)}\right)^{\theta\rho} \pi_t^{\rho}\right]^{\frac{1}{\rho-1}} + \left[\frac{\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}}}{1-\theta}\right]^{\frac{1}{\rho-1}}\right)^2}.$$

It can be verified that the sign of $\frac{\partial n^*}{\partial \bar{n}}$ depends on the sign of the term $-\frac{\rho\varepsilon}{\rho-1}$. Since $\rho < 1$, $-\frac{\rho\varepsilon}{\rho-1} > 0$, therefore, $\frac{\partial n^*}{\partial \bar{n}} > 0$.

A4. Proof of Proposition 3.4

Taking the first-order derivative of (21) is unwieldy for a general case. However, we are interested mostly in the case when individual human capital is high enough and we can find a reversal of fertility for these high-income individuals. In other words, we aim to ascertain whether we can establish a similar U-shaped pattern in the fertility-human capital relationship as was found by Hazan and Zoabi (2015). To simplify our calculations in the narrowly defined range of human capital, we assume that the level of human capital is high enough so that $\frac{\partial \pi}{\partial h_i} = 0$. Now, to make our calculations more tractable, we introduce axillary notations:

$$n_{it}^* = \frac{\left[\frac{\psi_1 h_{it}^{\rho-1} + \psi_2 h_{it}^{\frac{1-\phi}{\phi}+\rho-1}}{(1-\theta)}\right]^{\frac{1}{\rho-1}}}{\left[\frac{(1-\alpha)}{\alpha} \bar{c}_t^{-\rho\delta} \bar{n}_t^{\rho\varepsilon} \left(\bar{h}_t^{1-\beta} h_{it}^{\beta}\right)^{\rho(1-\theta)} \left(\frac{\theta(\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}})}{(1-\theta)}\right)^{\theta\rho} \pi_t^{\rho}\right]^{\frac{1}{\rho-1}} + \left[\frac{\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}}}{1-\theta}\right]^{\frac{\rho}{\rho-1}}} = \frac{h\Pi_1}{\Pi_2 + \Pi_3}.$$

Here, $\Pi_1 = \left[\frac{\psi_1 + \psi_2 h_{it}^{\frac{1-\phi}{\phi}}}{1-\theta}\right]^{\frac{1}{\rho-1}}$,

$$\Pi_2 = \left[\frac{(1-\alpha)}{\alpha} \bar{c}_t^{-\rho\delta} \bar{n}_t^{\rho\varepsilon} \left(\bar{h}_t^{1-\beta} h_{it}^{\beta} \right)^{\rho(1-\theta)} \left(\frac{\theta(\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}})}{(1-\theta)} \right)^{\theta\rho} \pi_t^{\rho} \right]^{\frac{1}{\rho-1}},$$

$$\Pi_3 = \left[\frac{\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}}}{1-\theta} \right]^{\frac{\rho}{\rho-1}}.$$

By taking the first-order derivative, we obtain:

$$\frac{\partial n^*}{\partial h} = \frac{\frac{\partial(h_{it}\Pi_1)}{\partial h_{it}}(\Pi_2 + \Pi_3) - h_{it}\Pi_1 \frac{\partial(\Pi_2+\Pi_3)}{\partial h_{it}}}{(\Pi_2 + \Pi_3)^2}. \tag{36}$$

The elements of these expressions can be considered separately:

$$\frac{\partial(h_{it}\Pi_1)}{\partial h_{it}} = \frac{\partial}{\partial h_{it}} \left(h_{it} \left[\frac{\psi_1 + \psi_2 h_{it}^{\frac{1-\phi}{\phi}}}{1-\theta} \right]^{\frac{1}{\rho-1}} \right) =$$

$$= \left[\frac{\psi_1 + \psi_2 h_{it}^{\frac{1-\phi}{\phi}}}{1-\theta} \right]^{\frac{1}{\rho-1}} \left(1 - \frac{(1-\phi)\psi_2 h_{it}^{\frac{1-\phi}{\phi}}}{\phi(1-\rho)\left(\psi_1 + \psi_2 h_{it}^{\frac{1-\phi}{\phi}}\right)} \right) =$$

$$= \Pi_1 \left(1 - \frac{(1-\phi)\psi_2 h_i^{\frac{1-\phi}{\phi}}}{\phi(1-\rho)\left(\psi_1 + \psi_2 h_{it}^{\frac{1-\phi}{\phi}}\right)} \right).$$

$$\frac{\partial\Pi_2}{\partial h_{it}} = \frac{\partial}{\partial h_{it}} \left[\frac{(1-\alpha)}{\alpha} \bar{c}_t^{-\rho\delta} \bar{n}_t^{\rho\varepsilon} \left(\bar{h}_t^{1-\beta} h_{it}^{\beta} \right)^{\rho(1-\theta)} \left(\frac{\theta(\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}})}{(1-\theta)} \right)^{\theta\rho} \pi_t^{\rho} \right]^{\frac{1}{\rho-1}} =$$

$$= \left[\frac{(1-\alpha)}{\alpha} \bar{c}_t^{-\rho\delta} \bar{n}_t^{\rho\varepsilon} \bar{h}_t^{(1-\beta)(\rho(1-\theta)} \pi_t^{\rho} \left(\frac{\theta}{1-\theta} \right)^{\theta\rho} \right]^{\frac{1}{\rho-1}} \times$$

$$\left(\psi_1 h_{it}^{\frac{\beta(1-\theta)}{\theta}} + \psi_2 h_{it}^{\frac{\phi}{1-\phi} + \frac{\beta(1-\theta)}{\theta}} \right)^{\frac{\theta\rho}{\rho-1}} \frac{\theta\rho}{\rho-1} \times$$

$$
\times \frac{1}{h_{it}} \left(\frac{\frac{\beta(1-\theta)}{\theta}\psi_1 h_{it}^{\frac{\beta(1-\theta)}{\theta}} + \left(\frac{\phi}{1-\phi} + \frac{\beta(1-\theta)}{\theta}\right)\psi_2 h_{it}^{\frac{\phi}{1-\phi}+\frac{\beta(1-\theta)}{\theta}}}{\left(\psi_1 h_{it}^{\frac{\beta(1-\theta)}{\theta}} + \psi_2 h_{it}^{\frac{\phi}{1-\phi}+\frac{\beta(1-\theta)}{\theta}}\right)} \right).
$$

Given that $\frac{\beta(1-\theta)}{\theta} < 1$ and $\left(\frac{\phi}{1-\phi} + \frac{\beta(1-\theta)}{\theta}\right) < 1$, the last term of the above expression can be simplified as $\frac{\chi_2}{h_{it}}$, where $\chi_2 = \left(\frac{\frac{\beta(1-\theta)}{\theta}\psi_1 h_{it}^{\frac{\beta(1-\theta)}{\theta}} + \left(\frac{\phi}{1-\phi} + \frac{\beta(1-\theta)}{\theta}\right)\psi_2 h_{it}^{\frac{\phi}{1-\phi}+\frac{\beta(1-\theta)}{\theta}}}{\psi_1 h_{it}^{\frac{\beta(1-\theta)}{\theta}} + \psi_2 h_{it}^{\frac{\phi}{1-\phi}+\frac{\beta(1-\theta)}{\theta}}} \right)$

is a function defined in the range $(0,1)$. Thus, we can write:

$$
\frac{\partial \Pi_2}{\partial h_{it}} = \frac{\Pi_2 \theta \rho}{\rho - 1}\frac{\chi_2}{h_{it}}.
$$

The last element of (36) is given by:

$$
\frac{\partial \Pi_3}{\partial h_{it}} = \frac{\partial}{\partial h_{it}} \left(\frac{\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}}}{1-\theta} \right)^{\frac{\rho}{\rho-1}} = \frac{\rho \Pi_3}{(\rho-1)(\psi_1 + \psi_2 h_{it}^{\frac{\phi}{1-\phi}})} \times
$$

$$
\times \frac{\phi}{1-\phi}\frac{\psi_2 h_{it}^{\frac{\phi}{1-\phi}}}{h_{it}}.
$$

Similar to the previous case, we denote the ratio $\frac{\psi_2 h_{it}^{\frac{\phi}{1-\phi}}}{\psi_1 + \psi_2 h_i^{\frac{\phi}{1-\phi}}}$ by a function χ_3 that is bounded above. It can be verified that $\lim\limits_{h \to \infty} \chi_3 \to 1$. Thus, we write

$$
\frac{\partial \Pi_3}{\partial h_{it}} = \frac{\rho \Pi_3}{(\rho-1)}\frac{\phi}{(1-\phi)}\frac{\chi_3}{h_{it}}.
$$

Therefore, by denoting $\chi = \frac{\theta \rho}{1-\rho}\chi_2 + \frac{\rho \phi}{(1-\rho)(1-\phi)}\chi_3$, we can write

$$
\frac{\partial n_{it}^*}{\partial h_{it}} = \frac{\Pi_1(\Pi_2 + \Pi_3)}{(\Pi_2 + \Pi_3)^2} \times
$$

$$
\times \left(1 - \frac{\psi_2(1-\phi)}{(1-\rho)\phi\left(\frac{\psi_1}{h_{it}^{\frac{\phi}{1-\phi}}} + \psi_2\right)} + \chi \right). \tag{37}
$$

The sign of $\frac{\partial n_{it}^*}{\partial h_{it}}$ depends on the sign of the last term of (37) in brackets. By denoting $\tilde{h} = \left(\frac{[(1+\chi)(1-\rho)]\phi\psi_1}{\psi_2[1+\chi\phi(1-\rho)-\phi\rho]} \right)^{\frac{\phi}{1-\phi}}$, we can write the following conditions:

$$\frac{\partial n_{it}^*}{\partial h_{it}} \begin{cases} < 0, \text{if } h_{it} < \tilde{h}, \\ = 0, \text{if } h_{it} = \tilde{h}, \\ > 0, \text{if } h_{it} > \tilde{h}. \end{cases} \tag{38}$$

A5. Proof of Proposition 3.5

In this case, we take into account that the utility function of an agent is given by:

$$U = \gamma \left[\alpha(v^\delta c_{it})^\rho + (1-\alpha)(n_{it}\bar{n}^\varepsilon \left(\bar{h}_t^{1-\beta}h_{it}^\beta \right)^{1-\theta} e_{it}^\theta)^\rho \right]^{\frac{1}{\rho}},$$

where $v = v(\bar{c}) \in R^+$, $\frac{\partial v}{\partial \bar{c}} \gtrless 0$, $\frac{\partial^2 v}{\partial \bar{c}^2} < 0$. One can obtain the following solution for the fertility rate:

$$n_{it}^* = \frac{\left[\frac{\psi_1 h_{it}^{\rho-1}+\psi_2 h_{it}^{\frac{1-\phi}{\phi}+\rho-1}}{(1-\theta)} \right]^{\frac{1}{\rho-1}}}{\left[\frac{(1-\alpha)}{\alpha}v_t^{-\rho\delta}\bar{n}_t^{\rho\varepsilon} \left(\bar{h}_t^{1-\beta}h_{it}^\beta \right)^{\rho(1-\theta)} \left(\frac{\theta(\psi_1+\psi_2 h_{it}^{\frac{\phi}{1-\phi}})}{(1-\theta)} \right)^{\theta\rho} \pi_t^\rho \right]^{\frac{1}{\rho-1}} + \left[\frac{\psi_1+\psi_2 h_{it}^{\frac{\phi}{1-\phi}}}{1-\theta} \right]^{\frac{\rho}{\rho-1}}}. \tag{39}$$

$$\frac{\partial n_{it}^*}{\partial \bar{h}_t} = -\frac{\rho}{\rho-1} \times$$

$$\frac{\left(\frac{\psi_1 h_{it}^{\rho-1}+\psi_2 h_{it}^{\frac{1-\phi}{\phi}+\rho-1}}{(1-\theta)} \right)^{\frac{1}{\rho-1}} \left[\frac{(1-\alpha)}{\alpha}\bar{n}_t^{\rho\varepsilon}h_{it}^{\beta\rho(1-\theta)} \left(\frac{\theta(\psi_1+\psi_2 h_{it}^{\frac{\phi}{1-\phi}})}{(1-\theta)} \right)^{\theta\rho} \right]^{\frac{1}{\rho-1}} \left(\bar{h}_t^{(1-\theta)(1-\beta)}\pi\bar{c}_t^{-\delta} \right)^{\frac{\rho}{\rho-1}-1}}{\left(\left[\frac{(1-\alpha)}{\alpha}\bar{c}_t^{-\rho\delta}\bar{n}_t^{\rho\varepsilon} \left(\bar{h}_t^{1-\beta}h_{it}^\beta \right)^{\rho(1-\theta)} \left(\frac{\theta(\psi_1+\psi_2 h_{it}^{\frac{\phi}{1-\phi}})}{(1-\theta)} \right)^{\theta\rho} \pi_t^\rho \right]^{\frac{1}{\rho-1}} + \left[\frac{\psi_1+\psi_2 h_{it}^{\frac{\phi}{1-\phi}}}{1-\theta} \right]^{\frac{1}{\rho-1}} \right)^2} \times$$

$$\times \left(\frac{\rho}{\rho-1} \right) \left(\bar{h}_t^{(1-\theta)(1-\beta)}\pi v^{-\delta} \right) \left(\frac{(1-\theta)(1-\beta)}{\bar{h}} + \frac{1}{\pi}\frac{\partial \pi_t}{\partial \bar{h}_t} - \frac{\delta}{v}\frac{\partial v}{\partial \bar{c}_t}\frac{\partial \bar{c}_t}{\partial \bar{h}_t} \right). \tag{40}$$

39

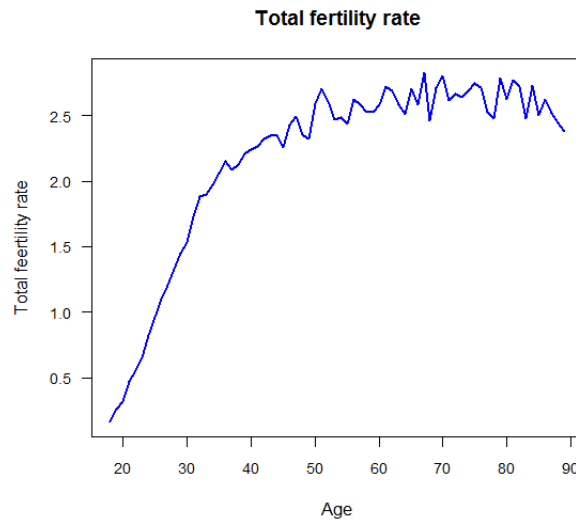When $\bar{c} > \bar{c}_m$ such that $\frac{\partial v}{\partial \bar{c}} < 0$, and since $\frac{\partial \bar{c}_t}{\partial \bar{h}_t} > 0$, it implies that

$$\left(\frac{(1-\theta)(1-\beta)}{\bar{h}_t} + \frac{1}{\pi_t} \frac{\partial \pi_t}{\partial \bar{h}_t} - \frac{\delta}{v} \frac{\partial v}{\partial \bar{c}_t} \frac{\partial \bar{c}_t}{\partial \bar{h}_t} \right) > 0.$$

Since $\left(\frac{\rho}{\rho-1} \right) < 0$ by definition, the expression in the numerator of (40) is positive; and thus, $\frac{\partial n_{it}}{\partial \bar{h}_t} > 0$.

B1. Fertility by age

Figure 5. Total fertility by age

Total fertility rate

The dataset is obtained from the National Opinion Research Center's General Social Survey, http://www.norc.org/.The survey data are not longitudinal. In this study, data from surveys of the period between 1972 and 2014 are used.

References

Abel, A. (1990). Asset prices under habit formation and catching up with the Joneses. *American Economic Review 80*, 38–42.

Bar, M. and O. Leukhina (2010). Demographic transition and industrial revolution: A macroeconomic investigation. *Review of Economic Dynamics 13*(2), 424 – 451.

Bhattacharya, J. and S. Chakraborty (2012). Fertility choice under child mortality and social norms. *Economics Letters 115*(3), 338–341.

Blackburn, K. and G. P. Cipriani (2002). A model of longevity, fertility and growth. *Journal of Economic Dynamics and Control 26*(2), 187–204.

Blume, L. E., W. A. Brock, S. N. Durlauf, and Y. M. Ioannides (2011). Chapter 18 - identification of social interactions§. Volume 1 of *Handbook of Social Economics*, pp. 853 – 964. North-Holland.

Bongaarts, J. and T. Sobotka (2012). A demographic explanation for the recent rise in European fertility. *Population and Development Review 38*(1), 83–120.

Brock, W. A. and S. N. Durlauf (2001). Chapter 54 - interactions-based models. Volume 5 of *Handbook of Econometrics*, pp. 3297 – 3380. Elsevier.

Chen, B.-L., Y.-S. Hsu, and K. Mino (2015). Welfare implications and equilibrium indeterminacy in a two-sector growth model with consumption externalities. *Macroeconomic Dynamics 19*, 535–577.

Day, C. (2016). Fertility and economic growth: The role of workforce skill composition and child care prices. *Oxford Economic Papers 68*(2), 546–565.

de la Croix, D. and M. Doepke (2003). Inequality and growth: Why differential fertility matters. *American Economic Review 93*, 1091–1113.

Doepke, M. (2004). Accounting for fertility decline during the transition to growth. *Journal of Economic Growth 9*, 347–383.

Doepke, M. (2005). Child mortality and fertility decline: Does the Barro-Becker model fit the facts? *Journal of Population Economics 18*(2), 337–366.

Fioroni, T. (2010). Child mortality and fertility: Public versus private education. *Journal of Population Economics 23*, 73–97.

Galor, O. (2005). From stagnation to growth: Unified growth theory. In P. Aghion and S. Durlauf (Eds.), *Handbook of Economic Growth*, Volume 1 of *A*, pp. 171–293. Amsterdam, Netherlands: Elsevier.

Galor, O. and D. Weil (2000). Population, technology and growth: From the malthusian regime to the demographic transition. *American Economic Review 110*, 806–828.

Goldstein, J. R., T. Sobotka, and A. Jasilioniene (2009). The end of "lowest-low" fertility? *Population and Development Review 35*(4), 663–699.

Goto, H. (2008). Social norms, inequality and fertility. *Economics Bulletin 10*(13), 1–9.

Hazan, M. and H. Zoabi (2005). Does longevity cause growth? a theoretical critique. *Journal of Economic Growth 11*(4), 363–376.

Hazan, M. and H. Zoabi (2015). Do highly educated women choose smaller families? *The Economic Journal 125*(587), 1191–1226.

Jones, L. E. and A. Schoonbroodt (2016). Baby busts and baby booms: The fertility response to shocks in dynastic models. *Review of Economic Dynamics 22*, 157–178.

Jones, L. E., A. Schoonbroodt, and M. Tertilt (2010). *Fertility Theories: Can They Explain the Negative Fertility-Income Relationship?*, pp. 43–100. University of Chicago Press.

Kalemli-Ozcan, S. (2002). Does the mortality decline promote economic growth? *Journal of Economic Growth 7*(4), 411–439.

Kalemli-Ozcan, S. (2003). A stochastic model of mortality, fertility, and human capital investment. *Journal of Development Economics 70*(1), 103–118.

Lanzieri, G. (2013). Towards a 'baby recession' in Europe? Statistics in focus 13, Eurostat, Statistics in focus 13/2013.

Ljungqvist, L. and H. Uhlig (2000). Tax policy and aggregate demand management under catching up with Joneses. *American Economic Review 90*, 356–366.

Luci, A. and O. Thévenon (2011). Does economic development drive the fertility rebound in OECD countries? *Population and Societies 481*, 1–4.

Manski, C. F. (1993). Identification of endogenous social effects: The reflection problem. *The Review of Economic Studies 60*, 531–542.

Manuelli, R. E. and A. Seshadri (2009). Explaining international fertility differences. *The Quarterly Journal of Economics 124*(2), 771– 807.

Monte, L. M. and R. R. Ellis (2012). Fertility of women in the United States. Technical report, U.S. Department of Commerce.

Morand, O. (1999). Endogenous fertility, income distribution, and growth. *Journal of Economic Growth 4*(3), 331–349.

Munshi, K. and J. Myaux (2006). Social norms and the fertility transition. *Journal of Development Economics 80*(1), 1–38.

Myrskylä, M., H.-P. Kohler, and F. Billari (2009). Advances in development reverse fertility declines. *Nature 460*(7256), 741–743.

Omori, T. (2009). Effects of public education and social security on fertility. *Journal of Population Economics 22*, 585–601.

Palivos, T. (2001). Social norms, fertility and economic development. *Journal of Economic Dynamics and Control 25*(12), 1919–1934.

Sander, W. (1992). The effect of women's schooling on fertility. *Economics Letters 40*, 229–233.

Strulik, H. (2004). Economic growth and stagnation with endogenous health and fertility. *Journal of Population Economics 17*(3), 433–453.

Tamura, R. (2002). Human capital and the switch from agriculture to industry. *Journal of Economic Dynamics and Control 27*(2), 207–242.

Ulph, D. (2014). Keeping up with the Joneses: Who loses out? *Economic Letters 125*, 400–403.